MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2015/2016

EME1046 – PRINCIPLES OF THERMODYNAMICS

(ME)

10 OCTOBER 2015
9.00 a.m – 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 5 printed pages (including cover page) with five questions.

2. Attempt **ALL FIVE** questions. All questions carry equal marks and the distribution of the marks for each question is shown.

3. Please write all your answers in the Answer Booklet provided.

4. A property tables booklet is provided. It need to be returned after the examination.

5. All necessary workings MUST be shown.

Question 1

5 kg of steam at 500 kPa, with a quality of 60 percent at state 1 experiences an isobaric process to state 2 where the temperature is been raised to 300 °C. It then undergoes an isothermal process to state 3 where the pressure has been raised to 10 MPa.

a) Find the initial temperature at state 1. [1 mark]

b) Find the numerical values of the specific volume and specific internal energy at each of the 3 states using the Property Tables Booklet provided [8 marks]

c) Sketch the processes on i) a P-v diagram,
ii) a T-v diagram,
with respect to the saturated liquid and saturated vapor lines. Label all the states and use arrows to indicate the direction of the processes. [6 marks]

d) For the isobaric process from state 1 to state 2, calculate :
i) the work done by the steam and,
ii) the heat transferred to the steam.
[5 marks]

Continued...

Question 2

a) Show that the general expression for the boundary work during an isothermal compression process of an ideal gas in a piston-cylinder is given by :

$$W_b = mRT \ln \frac{V_2}{V_1},$$

where m = the total mass of the ideal gas in the piston-cylinder,
R = gas constant,
T = the isothermal temperature, and
V_1 and V_2 = the initial and final volume of the system

[6 marks]

b) A mass of air is contained in a piston-cylinder device at 280 kPa and 127 °C as a closed system. 2000 kJ of heat is transferred to the system during an isothermal process where the pressure is been reduced to 70 kPa.
The kinetic and potential energy changes are negligible.
Given the gas constant of air R = 0.2870 kJ/kgK,

i) Determine the amount of work produced (kJ) during the isothermal process. [4 marks]

ii) Determine the mass of air in the piston-cylinder. [6 marks]

c) Air at 400 K and 200 kPa is heated at constant pressure to 600 K.
Determine the change in specific enthalpy by using the average specific heat value.

[4 marks]

Continued...

Question 3

Steam enters a well-insulated mixer nozzle system as shown below in Figure 1, with two inlets and one outlet operating at steady state. At inlet 1, water enters at pressure $P_1 = 8$ bar, temperature $T_1 = 160°C$, and inlet area $A_1 = 0.1$ m^2. At inlet 2, steam enters with mass flow rate $\dot{m}_2 = 20$ kg/s, at pressure $P_2 = 8$ bar, and $V_2 = 4$ m/s. At exit 3, saturated mixture leaving at pressure $P_3 = 8$ bar, quality $x_3 = 0.5$, $\dot{m}_3 = 43.5$ kg/s and velocity $V_3 = 60$ m/s. Neglecting the potential energy effect, determine:

a) The mass flow rate of the water at inlet $\dot{m}_1$. [3 marks]
b) The velocity of the fluid at inlet 1, V_1 [3 marks]
c) The temperature of the fluid at inlet T_2, [7 marks]
e) The entropy generation of the mixer nozzle system [5 marks]
f) Is the process possible? Why? [2 marks]

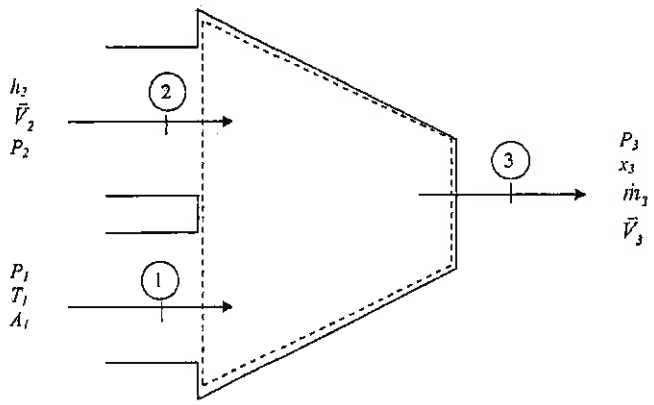

Figure Q3

Question 4

a) Draw the Carnot cycle on a T-S diagram of temperature (vertical-axis) vs. entropy (horizontal axis) and describe briefly the processes occurring during the cycle. [4 marks]

b) From the above T-S diagram explain how to determine the heat energy enters, Q_{in}, heat energy leaves, Q_{out} and net work done, W_{net} of the system. [6 marks]

c) Heat pump is used for heating the premises in winter and cooling the same during summer such that temperature inside remains 25 °C. Heat transfer across the walls and roof is found 2 MJ per hour per degree temperature difference between interior and exterior. Determine the minimum power required for operating the pump in winter when outside temperature is 1 °C and also give the maximum temperature in summer for which the device shall be capable of maintaining the premises at desired temperature for same power input.

[10 marks]

Continued...

Question 5

a) Consider a condenser rejects waste heat to the nearby river at 30 °C at a rate of 2000 kJ/kg. Steam enters the condenser at 10 kPa, 80 percent quality and leaves at 35 °C. Assuming no pressure change across the condenser and the change in kinetic and potential energy can be neglected, determine:

i) The entropy change of the river. [3 marks]
ii) The entropy change of the steam in the condenser. [3 marks]
iii) The total entropy change for this heat transfer process. [2 marks]
iii) Is this a reversible, irreversible or impossible heat transfer process? Why? [2 marks]

b) An insulated piston-cylinder device contains 5 L of saturated liquid water at a constant pressure of 150 kPa. An electric resistance heater inside the cylinder is now turned on, and 2200 kJ of energy is transferred to the system. Determine the entropy change of the water during this process.

[10 marks]

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